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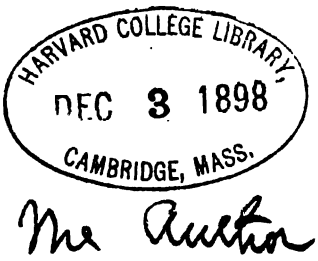

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Preface

This essay, reprinted with little alteration from the Journal of communication, of May and September, 1897, is mainly composed of data meant to aid in or suggest study of a change of the base of numeric notation from ten to some other number, and of the means to that end.

I shall be glad to receive data for correcting or enlarging the list of references, or a copy of any other list that may be made.

Robert M. Pierce

Chicago, October 17th, 1898

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Problems of

Number and Measure

Who that can perform simple arithmetic processes has not noticed peculiarities of numbers, numerals, and measures? Who has not found "five, ten, fifteen, twenty, twenty-five, thirty . . ." easier to remember, than "seven, fourteen, twenty-one, twenty-eight, thirty-five, forty-two . . ."? Who knows not, that, though he often uses $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{3}{4}$, and $\frac{7}{8}$, he nevertheless dislikes to reduce these fractions, so convenient in measuring, into decimals, so convenient in calculating? Who that lives in the United States has not been struck with the fact that, though "two for five cents," or "two for a quarter," are common prices for things, yet there is a peculiar process involved in paying for a single thing bought separately at such prices?

Does there not persist an almost universal notion that there is a mysterious power possest by the number ten, in virtue of which it is responsible for the convenient properties of numbers? How many persons see clearly the truth that not only is ten not responsible for many, if any, of the convenient properties of numbers, but that ten is responsible for many of the inconvenient properties of numbers? How many have suspected that, as in a row of pease, there is no special difference between the tenth pea and any other pea, so, in general, there is no special difference between the tenth thing and any other thing? How many who have all their lives stopt and begun again at ten, then stopt and begun again at twenty, and so on, have thought that it might have been better to have stopt and begun again at eight, sixteen, twenty-four, and so on, or at twelve, twenty-four, thirty-six?

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In modern times this was clearly seen by Emanuel Swedenborg and king Charles 12th, of Sweden, about the year 1719, and by certain persons since that time. But, perhaps appalled at the immense possibilities of the idea, these persons have tended to remain inactive: one in the hope that government would act; an other because of the difficulty of selecting the best radix from the several radices better than ten; an other because civilization has advanced too far; and still an other because civilization has not advanced far enough. Political institutions are, however, by no means the only initiative centers of society. It may well be idle to postpone action till all voluntarily agree. It may be the law of progress "that one, or a few, shall propose; that the many shall assent in general; that the few shall then work out the details in part; that all shall then move on, and that in the erush the final form of the thing proposed shall emerge—never as proposed, but often better." So it may be with number. Though decimal arithmetic is universal, though metric systems based on it have gained some ground, both may be overthrown by reason, which may substitute a more nearly perfect system.

The beauty of the present decimal, or denal, arithmetic, depends not on the fact that ten is its radix, but on the principle of the Arabic, or Hindu, notation, as applied to both whole numbers and fractions. The principle of this notation, best shown in its graphic form, is that every number shall be exprest in terms of the powers of a single number taken as the radix; the figure in the units place representing so many times the radix to the zero power; the successive figures to the left of the units place representing successively increasing powers of the radix; and the successive figures to the right of the units place representing successively increasing negative powers of the radix.

Now, simply by giving to each of the integral parts, or units, of any number a distinctive name and graphic sign, we may use that number as the radix of a system of arithmetic in place of the present radix ten. The use of ten as a radix probably arose through a habit possest by our ancesters, in common with certain races of today, of counting on the ten fingers. This radix ten having thus arisen out of relation to those things which it is now most necessary to count and to divide, is perhaps one of

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the worst among those radices that may be used in future. Among the radices that may be more fit than ten, are eight, twelve, and sixteen. Let us see some of their advantages and let us formulate some of the problems which should be considered by psychologists, mathematicians, and other competent persons, in order that the most advantageous numeric and metric system may be workt out and introduced in the best manner.

First, let us understand clearly how it is that a simple row of figures, as, for example, 725.25, expresses a number.

Spreading the row out we have:

7 2 5. 2 5

which equals:

$$7(100) + 2(10) + 5(\tfrac{1}{10}) + 2(\tfrac{1}{10}) + 5(\tfrac{1}{100})$$

or:

$$7(10)^2 + 2(10)^1 + 5(10)^0 + 2(10)^{-1} + 5(10)^{-2}$$

Thus, it becomes clear that the way in which the figures in the row 725.25 represent a number is by indicating, according to their relative places, the number of times each of the successive positive and negative powers of the radix are contained in that number. It is evident that, if the figure 7 in this row of figures represented not seven times *ten* square, but seven times *eight* square, and if the other figures of the row represented two times *eight* to the first power, five times *eight* to the zero power, two times *eight* to the minus first power, and five times *eight* to the minus second power, respectively, the row as a whole would represent a number, but a number other than that which it commonly represents.

If, on the other hand, we have a number, say of pease, and wish to express this number, we may do so not only in lots of ten each, but in lots of eight each. Instead of saying we have "twenty-four" pease, or "two lots of ten pease each and four pease over," we may say that we have "three lots of eight pease each and no pease over." Thus we may reckon in lots of eight, twelve, or any other number, instead of ten.

In order, however, to use any other number, instead of ten, as a base or radix, it is necessary to associate a name and a graphic

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sign to each of the integral parts, or units, of that number, and to become familiar with the system of combinations thence arising, just as we have become familiar with the nomenclature of decimal arithmetic. Thus, if we use the number *eight* as a radix, we might retain the present names of the units from one to eight, inclusive, writing them thus: 1, 2, 3, 4, 5, 6, 7, 10. Nine might be called "eight-ty-one", and be written "11"; ten might be called "eight-ty-two", and be written "12"; and so on to sixteen, which might be called "two-eight", and be written "20"; seventeen being called "two-eight-ty-one" and written "21".

If we should use the number twelve as a radix, we might retain the present names and figures from one to nine, inclusive, adding a new name and a new figure for ten, an other for eleven, writing twelve "10", and giving it an appropriate name. So if we should use the number sixteen as a radix, we might have six new figures and appropriate names. If, however, the number two should be used as a radix, we might, with only two figures, say a "1" and a "2", and of course, a "0", write any number desired.

Though the retention of old associations might be advantageous, specially for small numbers corresponding to single figures, or simple combinations of figures, it is doubtful if, on the whole, any such nomenclature should be used, except in explanations to adult persons. For this purpose, and as a basis for the suggestions and problems to be presented further on, I insert in the following table certain possible nomenclatures for the octonal, the duodenal, and the sexidenal systems of numeric notation, parallel with the ordinary denal or decimal system. In the names in this table the letters represent the sounds which they represent in the phonic spellings of the words in the following list, in which the several letters are followed by examples of English words in which they occur, the current spelling of each word being followed by a phonic spelling in parentheses. The sign (:) is for length of sounds.

p, peat (pi:t); d, dale (de:l); t, tale (te:l); v, vat (vat); f, fat (fat); z, zeal (zi:l); s, seal (si:l); n, nail (ne:l); l, live (liv); u, pool (pu:l); o, own (o:n); ɑ, ask (ɑsk); e, pain (pe:n); i, peat (pi:t). The syllabic stress may be considered as uniform, if desired.

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octonal (base eight)	denal (base ten)	duodenal (base twelve)	sexidenal (base sixteen)
0 nul	0	0 nul	0 nul
1 an	1	1 an	1 an
2 tu	2	2 tu	2 tu
3 di	3	3 di	3 di
4 fo	4	4 fo	4 fo
5 fa	5	5 fa	5 fa
6 si	6	6 si	6 si
7 ze	7	7 ze	7 ze
10 ton	8	8 et	8 et
11 tonan	9	9 na	9 na
12 tontu	10	a te	a te
13 tondi	11	b le	b le
14 tonfo	12	10 ton	c va
15 tonfa	13	11 tonan	d la
16 tonsi	14	12 tontu	e po
17 tonze	15	13 tondi	f fu
20 tuton	16	14 tonfo	10 ton
21 tutonan	17	15 tonfa	11 tonan
22 tutontu	18	16 tonsi	12 tontu
	19	17 tonze	13 tondi
	20	18 tonet	14 tonfo
	21	19 tonna	15 tonfa
	22	1a tonte	16 tonsi
	23	1b tonle	17 tonze
	24	20 tuton	18 tonet
	25	21 tutonan	19 tonna
	26	22 tutontu	1a tonte
	27		1b tonle
	28		1c tonva
	29		1d tonla
	30		1e tonpo
	31		1f tonfu
	32		20 tuton
	33		21 tutonan
	34		22 tutontu

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To translate[1] any whole number from decimal notation into any other notation, one may proceed as follows: divide the number (as decimally exprest) by the radix of the new notation (decimally exprest). The remainder (after being translated into the new notation) is the figure of the units place in the desired new notation of the number. If the quotient is smaller than the radix of the new notation, it (after being translated into the new notation) is the second, or left-hand, figure in the desired new notation of the number. If, however, the quotient obtained by the first division is greater than the radix of the new notation, divide it by the new radix and note the remainder. Proceed as before till a quotient is obtained that is less than the new radix. The series of remainders and this last quotient (all appropriately exprest) constitute, when arranged from right to left, the desired new notation of the number.

For example: to translate the number "twenty-four," exprest decimally as "24," into a notation whose radix is eight, we have only to divide 24 by 8 once. The remainder is 0; the quotient is 3. Thus the number "twenty-four" may be exprest in the octonal notation suggested in the above table as "30," or, vocally, as "diton." "Twenty-four" is three times eight ($24 = 3 \times 8$), or, octonally, diton is di times ton ($30 = 3 \times 10$).

To show the details of a more complex case, let us translate the denal expression 768923 into duodenal notation:

12) 768923		
12) 64076	11 = b	(duodenal)
12) 5339	8 = 8	"
12) 444	11 = b	"
12) 37	0 = 0	"
3	1 = 1	"

768923 (denal) = 310b8b (duodenal).

[1] For the methods of translation here given I am indebted in part to James M. McKinlay of New York, who also suggested the use of the formulas used below for logarithms, and in part to Edwin S. Crawley of the mathematic department of the University of Pennsylvania, Philadelphia.

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For translating a decimal fraction into any other notation, we may multiply successively by the radix of the new notation, instead of dividing, as in the case of a whole number. The series of integral portions of the successive products (after being translated into the new notation) constitute, when arranged from left to right, the desired new notation of the fraction.

The details of the process may be seen in the following translation of the denal expression 0.975 into sexidenal notation:

$$\begin{array}{r} .975 \\ 16 \\ \hline (15).600 \\ 16 \\ \hline (9).600 \\ 16 \\ \hline (9).600 \end{array}$$

0.975 (denal) = 0.f99 . . . (sexidenal).

For, if we

let x = the number of sixteenths in 0.975,
then:

$$\begin{aligned} x &= 0.975 \div \tfrac{1}{16} \\ &= 0.975 \times 16 \\ &= 15.600 \end{aligned}$$

That is, there are 15 even sixteenths in 0.975. The sexidenal expression of what is decimally exprest by "15" then, or "f," is the figure which, in sexidenal notation of the decimal fraction 0.975, occupies the place just to the right of the units place, or point. Similarly the reason for the rest of the above processes may be shown.

In the following table are some common fractions. Opposit them are their equals in octonal, denal, duodenal, and sexidenal notations, showing the relative complexity of their notation in the current decimal or denal system:

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	octonal	denal	duodenal	sexidenal
$\frac{1}{2}$	0.4	0.5	0.6	0.8
$\frac{1}{4}$	0.2	0.25	0.3	0.4
$\frac{3}{4}$	0.6	0.75	0.9	0.c
$\frac{1}{8}$	0.1	0.125	0.16	0.2
$\frac{3}{8}$	0.3	0.375	0.46	0.6
$\frac{5}{8}$	0.5	0.625	0.76	0.a
$\frac{7}{8}$	0.7	0.875	0.a6	0.e
$\frac{1}{3}$	0.25252	0.33333	0.4	0.55555 ....
$\frac{1}{6}$	0.12525	0.16666	0.2	0.2aaaa ....
$\frac{1}{9}$	0.08708	0.11111	0.14	0.1c71c ....
$\frac{1}{16}$	0.04	0.0625	0.09	0.1
$\frac{1}{32}$	0.02	0.03125	0.046	0.08

Multiplication tables for the octonal, denal, duodenal, and sexidenal systems may be arranged as follows, for comparison or acquisition. All repetitions of the same product in the same table, that is, all second or other occurrences of the same number, are in italic.

octonal

	2	3	4	5	6	7
7	16	25	34	43	52	61
6	14	22	30	36	44	*52*
5	12	17	24	31	*36*	*43*
4	10	*14*	20	*24*	*30*	*34*
3	6	11	*14*	*17*	*22*	*25*
2	4	*6*	*10*	*12*	*14*	*16*

denal

	2	3	4	5	6	7	8	9
9	18	27	36	45	54	63	72	81
8	16	24	32	40	48	56	64	*72*
7	14	21	28	35	42	49	*56*	*63*
6	12	*18*	*24*	30	*36*	*42*	*48*	*54*
5	10	15	20	25	*30*	*35*	*40*	*45*
4	8	*12*	*16*	*20*	*24*	*28*	*32*	*36*
3	6	9	*12*	*15*	*18*	*21*	*24*	*27*
2	4	*6*	*8*	*10*	*12*	*14*	*16*	*18*

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duodenal

	2	3	4	5	6	7	8	9	a	b
b	1a	29	38	47	56	65	74	83	92	a1
a	18	26	34	42	50	5a	68	76	84	*92*
9	16	23	30	39	46	53	60	69	*76*	*83*
8	14	20	28	*34*	40	48	54	*60*	*68*	*74*
7	12	19	24	2b	36	41	*48*	*53*	*5a*	*65*
6	10	*16*	20	*26*	*30*	*36*	*40*	*46*	*50*	*56*
5	a	13	*18*	*21*	*26*	*2b*	*34*	*39*	*42*	*47*
4	8	10	14	*18*	*20*	*24*	*28*	*30*	*34*	*38*
3	6	9	*10*	*13*	*16*	*19*	*20*	*23*	*26*	*29*
2	4	*6*	*8*	*a*	*10*	*12*	*14*	*16*	*18*	*1b*

sexidenal

	2	3	4	5	6	7	8	9	a	b	c	d	e	f
f	1e	2d	3c	4b	5a	69	78	87	96	a5	b4	c3	d2	e1
e	1c	2a	38	46	54	62	70	7e	8c	9a	a8	b6	c4	*d2*
d	1a	27	34	41	4e	5b	68	75	82	8f	9c	a9	*b6*	*c3*
c	18	24	30	*3c*	48	*54*	60	6c	*78*	84	90	*9c*	*a8*	*b4*
b	16	21	2c	37	42	4d	58	63	6e	79	*84*	*8f*	*9a*	*a5*
a	14	1e	28	32	*3c*	*46*	50	*5a*	64	*6e*	*78*	*82*	*8c*	*96*
9	12	1b	*24*	*2d*	36	3f	*48*	51	*5a*	*63*	*6c*	*75*	*7e*	*87*
8	10	18	20	*28*	*30*	*38*	40	*48*	*50*	*58*	*60*	*68*	*70*	*78*
7	e	15	1c	23	*2a*	31	*38*	*3f*	*46*	*4d*	*54*	*5b*	*62*	*69*
6	c	12	*18*	*1e*	*24*	*2a*	*30*	*36*	*3c*	*42*	*48*	*4e*	*54*	*5a*
5	a	f	14	19	*1e*	*23*	*28*	*2d*	*32*	*37*	*3c*	*41*	*46*	*4b*
4	8	c	*10*	*14*	*18*	*1c*	*20*	*24*	*28*	*2c*	*30*	*34*	*38*	*3c*
3	6	9	*c*	*f*	*12*	*15*	*18*	*1b*	*1e*	*21*	*24*	*27*	*2a*	*2d*
2	4	*6*	*8*	*a*	*c*	*e*	*10*	*12*	*14*	*16*	*18*	*1a*	*1c*	*1e*

Some examples of ordinary arithmetic processes are as follows:

addition

octonal		denal		duodenal		sexidenal
30	=	24	=	20	=	18
20	=	16	=	14	=	10
50	=	40	=	34	=	28

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subtraction

octonal		denal		duodenal		sexidenal
30	=	24	=	20	=	18
20	=	16	=	14	=	10
10	=	8	=	8	=	8

multiplication

octonal		denal		duodenal		sexidenal
30	=	24	=	20	=	18
20	=	16	=	14	=	10
00		144		80		00
60		24		20		18
600	=	384	=	280	=	180

division

octonal	denal	duodenal	sexidenal
20)30.0(1.4	16)24.0(1.5	14)20.0(1.6	10)18.0(1.8
20	16	14	10
100	80	80	80
100	80	80	80

The ordinary logarithm of a number being the index of the power to which the radix of the current arithmetic, ten, must be raised in order to equal that number, the expression of the logarithm of any number (as 3) in any system other than the decimal may be found by the following formula, in which r equals the new radix and x equals the desired logarithm:

$$r^x = 3$$
$$x \times \log r = \log 3$$
$$\log\ x = \log \text{ of } \log 3 - \log \text{ of } \log r$$

By tables of ordinary logarithms the value of x in this equation may be found, and by the methods given above the value so found may be translated into the appropriate notation.

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The number of places, or figures, required to express a number in different systems of notation, is said to vary inversely as the logarithms of the radices of those systems. Thus, a number exprest in the decimal system by 3 figures requires 10 figures for its expression in the binal system; while a number exprest in the decimal system by 9 figures requires 10 figures for its expression in the octonal system. This inverse ratio of the logarithms of the radices is not, however, the ratio of the number of figures required for the *calculations* performed with numbers. For example, to write two numbers in the octonal system requires one-third as many figures as are required to write the same numbers in the binal system, but to multiply together these numbers in the octonal system requires only about one-fifth as many figures as are required to multiply together the same numbers in the binal system, even after allowing for saving of time by the occurrence of ciphers in the binal system.[1]

I can at present but suggest a few directions in which an examination of the problems connected with the practical introduction of these systems may tend. The facts to be ascertained might be arranged under four heads:

1. To find the condition of current opinion:

Send circulars or blanks with appropriate questions to mathematicians, metrologists, makers of calculating machines and metric apparatus, engineers, manufacturers, retail and wholesale merchants, teachers, and others.

2. To find the condition of current numeric power:

By systematic examination and experiment procure statistics of the ease with which the decimal system is learned, and the ease and correctness with which it is used, for both mental and graphic calculation, as well as for metric purposes.

3. To find the most desirable numeric system:

Ascertain the relative ease of acquiring new systems of notation, the ease and correctness with which these systems may be used when once acquired, in different styles both of verbal and

[1] According to W. W. Johnson, Octonary numeration. Bulletin of the New York Mathematical Society, 1 : 1 : 2.

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graphic terminology, and the relations of all these facts to each other and to the use of the current decimal system.

4. To find the best method of introducing the most desirable numeric system into ordinary use:

Examine the genesis of similar social changes, as the introduction of Arabic figures. Examine the facilities afforded by educational, industrial and other institutions for the introduction of new numeric systems. Examine different systems of numeric notation in relation to their application to existing systems or new systems of linear, surface and solid measures of space and of solid, liquid, and gaseous matter; to circular or other measures of time (clocks); to measures of forces, as heat; to measures of value or media of exchange (money); to calculating machines. Construct nomenclatures, vocal and graphic, for various numeric systems, and make tables for the translation of different numeric and metric systems into decimal numeric and metric systems, or the reverse.

Some References

Adams, John Quincy.

Report to the Senate and House of Representatives, Feb. 22d, 1821, on weights and measures.

Anderson.

Article Arithmetic in Brewster's Edinburgh encyclopedia, 2: 376.

Barnard, Frederick Augustus Porter.

The metric system of weights and measures. Revised ed. 194 p. 1872 Columbia College, New York. 456 p. 1879 American Metric Bureau, Boston. [base 10].

Bonaparte, Napoleon.

5 p. in History of France under Napoleon, by C. T. de Montholon, 0: 213. [bases 10 and 12].

Bowring, J.

Decimal system. 18 . . .

Digitized by Google

Bramwell, Frederick.

[Address before the Institution of Civil Engineers]. 18 . . .

Bryne, O.

Dual arithmetic, a new art. **1863** New York.

Dual arithmetic: descending. **1867** G. Bell and Sons, London.

Dual arithmetic for schools. **1866** G. Bell and Sons, London.

Young dual arithmetic. **1871** Spon, London.

Bulletin of the American Metric Bureau.

Jan. to Dec. **1878** American Metric Bureau, Boston. [base 10].

Cajori, Florian.

A history of mathematics. 422 p. **1893** (1895) Macmillan and Co., New York.

Chisholm, H. W.

The science of weighing and measuring. **1877** Macmillan and Co., London.

Coinage, weights, and measures, Committee of the House of Representatives of the United States on.

Hearing before. Relative to H. R. bill 2758. Jan. 30th, **1896.**

Metric weights and measures. A report by C. W. Stone, from the committee, to H. R., to accompany H. R. bill 7251. March 16th, **1896.**

Report of, to H. R. Part 1. On the adoption of the metric system of weights and measures, together with documents and statistics relating to the subject. Part 2. On metric coinage. **1879** Government Printing Office, Washington.

Colin, A.

The universal metric system. 49 p. 1876 D. Appleton and Co., New York. [base 10].

Colles, George W.

The metric versus the duodecimal system. A review of the facts. An address before the December meeting of the Ameri-

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can Society of Mechanical Engineers. 98 p. in transactions of the A. S. M. E., vol. 18. **1896.**

Conant, Levi Leonard.

The number consept. **18 . . .**

Crawley, Edwin S.

The origin and development of number systems. 11 p. in Appletons' popular science monthly August, p. 524. **1897.**

De Morgan, Agustus.

The decimalization of coinage. **Before 1871.**

Eastburn, George.

The metric system. 21 p. **1889** (1892) American Metrological Society, New York. [base 10].

Edinburgh review.

Jan. 9: 376. **1807.** [base 12].

Egleston, Thomas.

Tables of weights, measures, coins, etc. 60 p. **1880** American Metric Bureau, Boston.

Franklin Institute.

Reports to, on the metric system, May, **1876:** majority, by C. Sellers and W. P. Tatham; minority, by R. Briggs. Journal of F. I., Dec., 1876, p. 367. Proposed resolution, Journal, p. 371. Adopted resolution, Journal, Nov., 1876, 41: 39.

Frazer, Persifor, Jr.

The proposed substitution of the metric for our own system of weights and measures. Read before the Philadelphia Social Science Association, Dec. 28th, **1877.** 24 p. Reprint from Polytechnic review. [base 10].

Gore, J. H.

In American journal of science. **1891.**

Gow, James.

Short history of Greek mathematics, **18 . . .**

Hamilton-Smythe, A.

Paper before the Institute of Civil Engineers. **1885.**

Digitized by Google

Herschel, John.

Lecture before the Leeds Astronomical Society, Oct. 11th, 1863.

Hervas.

Arithmetica di quasi tutte le nazioni conosciute. 18...

Hilgard, J. E.

Report on the proposed international bureau of weights and measures at Paris. 18.. U. S. Coast Survey Office.

Husted, Albert Nathaniel.

The metric system: when shall it be made compulsory in the United States? 12 p. A paper read before the Albany, [N. Y.] Institute, January 5th, 1897.

International Association for Obtaining a Uniform Decimal System of Measures, Weights, and Coins, The.

Memorial to B. Disraeli, chancellor of her majesty's exchequer. Mar. 1859.

Jackson, L. D.

Simplified weights and measures. 1876 Spon, London.

Johnson, W. W.

Octonary numeration. 6 p. in Bulletin of the New York Mathematical Society, p. 1. Oct. 1891.

Leibnitz, Gottfried Wilhelm.

[On binary notation.] Before 1716.

Mendenhall, Thomas Corwin.

The metric system. 14 p. in Appletons' popular science monthly, Oct., p. 721. 1896 D. Appleton and Co. New York. [base 10].

Metric bulletin, The.

Official journal of American Metric Bureau. Monthly. July, 1876 to Dec., 1877 American Metric Bureau, Boston. [base 10].

Metric primer.

2d ed., 48 p. 1878 American Metric Bureau, Boston. [base 10].

Digitized by Google

Mouton, G.

1670 Lyons. [?]

Nordberg.

History of Charles 12th, of Sweden. **18 . . .**

Nystrom, John W.

Abstract of remarks before the Franklin Institute on the report of its committee on the compulsory use of the metric system. 4 p. in Journal of F. I., p. 385. **1876.** F. I. Philadelphia.

A new treatise on elements of mechanics . . . with an appendix on duodenal arithmetic and metrology. 352 p. **1875** Porter and Coates, Philadelphia.

Project of a new system of arithmetic, weight, measure, and coins, proposed to be called the tonal system, with 16 to the base, 106 p. **1859** (1862) J. B. Lippincott and Co., Philadelphia. Trübner and Co., London.

Peacock.

Article Arithmetic, in Encyclopedia metropolitana, 2: 392.

Phonetic journal, The.

1857 to **1858** I. Pitman, Bath. [base 12].

Pisano, L.

1202 Tuscany.

Putnam, J. P.

The metric system of weights and measures. 65 p. **1874** Rockwell and Churchill, Boston. 70 p. **1877** American Metric Bureau, Boston. [base 10].

Reed, Thomas Allen.

2 p. in A biography of Isaac Pitman, p. 77. **1890** Griffith, Farran, Okeden and Welsh, London. [base 12].

Rees, J. K.

The metric system. Detailed information as to laws, practice, etc. **1896** American Metrological Society, New York.

Sawyer, H. E.

Metric manual for schools. 3d ed. 64 p. **1877** American Metric Bureau, Boston. [base 10].

Digitized by Google

Sellers, Coleman.

Address at first annual meeting of the American Society of Mechanical Engineers. 18 . . .

Metric system in our workshops, etc., The. In Journal of the Franklin Institute, June, 1874 F. I. Philadelphia.

Report to the Franklin Institute . . . relative to the metric system of weights and measures. 8 p. in Journal of F. I., Dec., 1876, p. 370. Reprint, 1876 W. P. Kildare, Philadelphia.

Spencer, Herbert.

Against the metric system. In various fragments, p. 142. 1897 (1898) D. Appleton and Co., New York.

Swedenborg, Emanuel.

Compendium of the theological and spiritual writings of. (See life, p. 9, and appendix to life, etc., p. 123). 1854 Crosby and Nichols, A.

Proposal for fixing the value of coins and determining the measures of Sweden, so as to suppress fractions, and facilitate calculations, A. 1719. [base 8].

Taylor, Alfred B.

Report to American Pharmaceutical Association, Boston, Sept. 15th. 104 p. 1859. [base 8].

Vinton, F. L.

Engineering and mining journal, Dec. 22d, 1877.

Wagstaff, W. H.

The metric system of weights and measures. 125 p. 1896 Whittaker and Co., London.

Why the metric system?

15 p. reprint from Dry goods economist, Jan. 11th to March 14th, 1896 D. G. E. Press, New York.

Zehetmayr, S.

Etymology of numbers. 1854 Leipzig.

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Digitized by Google

Digitized by Google

Digitized by Google